# Digital Signals - Analog Data

Once analog data have been converted into digital data, a number of things can happen.

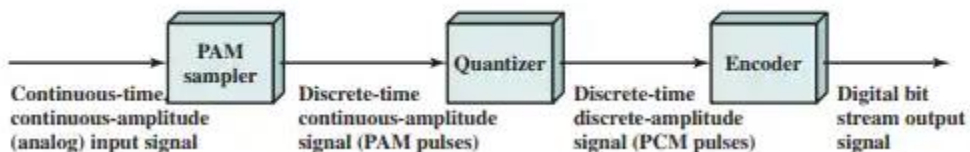**The three most common outcomes are the following:**

1. The digital data can be transmitted using NRZ-L. In this case, we have in fact gone directly from analog data to a digital signal.

2. The digital data can be encoded as a digital signal using a code other than NRZ-L. Thus an extra step is required.

3. The digital data can be converted into an analog signal, using one of the modulation techniques.

Analog data (voice) → Digitizer → Digital data → Modulator → Analog signal (ASK)
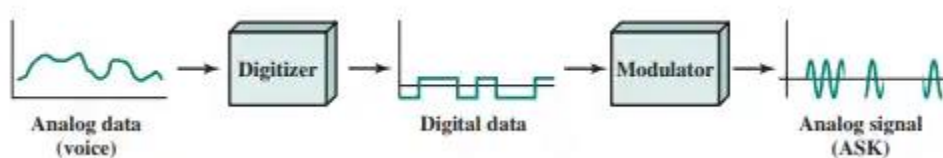
voice data that are digitized and then converted to an analog ASK signal. This allows digital transmission The voice data, because they have been digitized, can be treated as digital data, even though transmission requirements (e.g., use of microwave) dictate that an analog signal be used.

The device used for converting analog data into digital form for transmission, and subsequently recovering the original analog data from the digital, is known as a codec (coder-decoder). In this section, we examine the two principal techniques used in codecs: pulse code modulation and delta modulation.

Pulse Code Modulation

Continuous-time, continuous-amplitude (analog) input signal → PAM sampler → Discrete-time continuous-amplitude signal (PAM pulses) → Quantizer → Discrete-time discrete-amplitude signal (PCM pulses) → Encoder → Digital bit stream output signal

Thus, PCM starts with a continuous-time, continuous-amplitude (analog) signal, from which a digital signal is produced. The digital signal consists of blocks of n bits, where each n-bit number is the amplitude of a PCM pulse. On reception, the process is reversed to reproduce the analog signal. Notice, however, that this process violates the terms of the sampling theorem. By quantizing the PAM pulse, the original signal is now only approximated and cannot be recovered exactly. This effect is known as quantizing error or quantizing noise.